

CONCEPT PAPER

ENVIRONMENTAL AND ENERGY STANDARDS FOR HYDROGEN PRODUCTION SENATE BILL 1505

April 3, 2008

Introduction

In 2006, the legislature passed Senate Bill 1505 (SB 1505) calling for the Air Resources Board (ARB) to adopt regulations regarding environmental standards for hydrogen production. The standards are to ensure that when the California Hydrogen Highway Blueprint Plan is implemented it is done in an environmentally responsible manner. SB 1505 includes emission reduction standards as well as a renewable energy requirement. Staff has developed proposals for the adoption of this regulation, as presented in this white paper. Please note that staff will accept comments and suggestions through input during public workshops, direct contact and in writing.

Summary

SB 1505 directs ARB to develop a regulation for hydrogen fuel produced/dispensed for transportation use in California. The requirement will be in effect for state funded hydrogen stations once the regulation is adopted, and for hydrogen stations in California upon reaching a statewide annual throughput of 3,500 metric tons. Requirements include:

Reporting and review

- Providers of hydrogen fuel for transportation in the state report annual amount of hydrogen dispensed to ARB
- The state shall review emissions requirements every four years to determine if strengthening the requirements is necessary

Emissions

- 50 percent reduction of Oxides of Nitrogen (NOx) and Reactive Organic Gas (ROG) emissions as compared to gasoline production well-to-tank (WTT),
- 30 percent reduction of greenhouse gas emissions (GHG) as compared to gasoline well-to-wheel (WTW),
- no increase in toxic air contaminants (TAC) as compared to gasoline production WTT, and

Renewable

- 33.3 percent of the hydrogen must be made from eligible renewable resources.

Exemptions

The following is a list of exemptions outlined within the bill. The decision of whether or not to implement these exemptions will be determined through the regulatory development process.

Pre-threshold

- The Executive Officer can exempt state co-funded hydrogen stations that provide fuel to public transit operators from using eligible renewable resources for hydrogen production. The exemption would last up to five years and could be extended an additional five years if the Executive Officer deems it necessary.
- Following a public workshop, the Executive Officer may exempt small state co-funded demonstration or temporary facilities from the requirements for emission reductions and use of renewables for up to five years. The total hydrogen throughput of exempted facilities may not be greater than 10 percent of the hydrogen produced statewide for transportation within a one year period.
- If the state board determines that there is insufficient availability of hydrogen from eligible renewable resources to meet the 33.3 percent requirement, then after one workshop, and on a one time basis, reduce the requirement by 10 percentage points.

Post-threshold

- Regardless of funding sources, the Executive Officer may exempt stations that dispense no more than 100 kilogram (kg) a month from the requirements for emission reductions and use of renewable resources. The average annual mass of hydrogen dispensed from exempted facilities shall not exceed 10 percent of the total annual mass of hydrogen dispensed statewide for transportation. This exemption could last no more than five years.

Applicability

The regulation shall apply to providers of hydrogen used for transportation including providers of hydrogen for blending (e.g. hydrogen and compressed natural gas) and for home refueling appliances. Blending does not refer to hydrogen used in gasoline production. Examples of affected stakeholders include:

- Commercial stations that sell or provide hydrogen fuel
- Fuel providers servicing fleet vehicles
- Providers of hydrogen for use in off-road transportation applications
- All other providers of hydrogen fuel that is used for transportation

Following is a summary of the requirements that will be in effect once the regulation is adopted:

- Each provider of hydrogen for transportation shall submit quarterly reports that indicate the mass of hydrogen dispensed for transportation and the method of

production. The first report will be due to ARB six months following the adoption of the regulation. This includes hydrogen used in blending for direct use in transportation such as hydrogen natural gas blending.

- Providers of hydrogen for transportation that are awarded state funding after this regulation is adopted must satisfy the requirements for emissions reductions and use of renewable resources on a state wide basis.

Once the 3,500 metric ton threshold has been reached, the requirements for emissions reductions and use of renewable resources will apply to on average, all hydrogen stations in California as follows:

- Hydrogen stations constructed after this regulation is adopted; and
- For hydrogen stations constructed before the regulation is adopted, the requirements would be in effect when a station increases production and/or dispensing capacity, or changes hydrogen production technology.

Compliance path for home refueling appliances: Home refueling appliances will likely contribute to California's overall hydrogen fueling infrastructure but, at this time, it is difficult to predict the impact they will have on the state's total hydrogen-for-transportation output or associated emissions. For this reason, staff is proposing to require sellers of home refuelers to report the annual number of appliances sold and their capacity, rather than requiring individual reporting of hydrogen dispensed from each unit. Staff will periodically assess the contribution of home refuelers to the statewide throughput, then make a recommendation on whether to include or exempt them from the requirements of this regulation.

Assumptions for Emissions Modeling and Comparing

SB 1505 requires that emissions associated with hydrogen used as a vehicle fuel be lower than baseline gasoline values. Emissions values of NO_x plus ROG and TACs associated with hydrogen production will be compared on a WTT basis to the "average motor gasoline". Emissions of greenhouse gases will be compared on a WTW basis to the "average new gasoline vehicle". Hydrogen "produced for transportation" includes feedstock preparation and hydrogen production, purification, compression, and dispensing.

For this regulation, the "marginal" analysis applied in the State Alternative Fuels Plan (AB 1007¹) will be used for WTT emissions associated with both hydrogen and the average motor gasoline. The marginal analysis reflects the notion that new sources of

¹ J. Pont, Full Fuel Cycle Assessment: Well to Wheels Energy Inputs, Emissions and Water impacts State plan to increase the use of non-petroleum transportation fuels AB1007 (Pavely), California Energy Commission CEC-600-2007-004-F, June 2007 (<http://www.energy.ca.gov/2007publications/CEC-600-2007-004/CEC-600-2007-004-REV.PDF>)

fuel and energy will need to be built or imported to meet increasing transportation demands and uses the following assumptions:

- Marginal petroleum fuel demand will be met by importing finished liquid fuels to California;
- Electric power demands will be met by natural gas power generation with combined cycle combustion power turbines and renewable power that complies with California's Renewable Portfolio Standard;
- Emissions from new stationary sources meet local air permitting requirements (i.e., equipped with best available control technology and all emissions of NO_x and Volatile Organic Compounds (VOC) are offset);
- Emissions from fuel transport vehicles meet ARB's requirements; and
- Marginal natural gas supplies originate from outside California.

These assumptions are consistent with ARB's Low Carbon Fuel Standard (LCFS), State Alternative Fuels Plan (SAFP) and other fuel-related regulations.

Regulatory Requirements

1. Reporting and compliance

- a. Legislation – All providers of hydrogen fuel for transportation in the state report to ARB their annual mass of hydrogen dispensed, method of production and delivery. Additional reporting requirements are also included to ensure compliance with regulation.
- b. Intent –The reporting requirement allows ARB to determine when the threshold level of 3,500 metric tons is approaching. The intent of the threshold is to allow the hydrogen industry sufficient time and opportunity to develop economic pathways for hydrogen production, and allow early development of a hydrogen infrastructure.
- c. Discussion - ARB will regularly share the reported total annual mass of hydrogen dispensed for transportation within the state. This will enable industry to plan for future investments in clean hydrogen production methods and renewable energy resources.
- d. How can it be met? – Hydrogen providers will be required to report the amount of hydrogen dispensed in kilograms per quarter. Station owners will have full jurisdiction over who is responsible to report for their station. Although the specific reporting method has not been decided, electronic reporting methods are being considered, either an online form or downloadable file that can be electronically transferred or mailed. ARB will continue to work with the industry to develop a standardized reporting method.

- e. Requirement – ARB will require that each station owner in the state report the kilograms of hydrogen dispensed on a quarterly basis. Reporting by all stations of mass dispensed will begin within six months after adoption of the regulation. ARB is aware of the current accuracies associated with measuring dispensed hydrogen and will allow the reporting agency to supply amount of hydrogen dispensed with associated levels of accuracy. This process will be used until a standard measurement method is adopted. Stations receiving state funding will also be required to report the amount of renewable hydrogen dispensed, type of renewable resources used, GHG emissions, emissions of NOx plus ROG and TACs. After the 3,500 metric ton threshold is reached, regulated hydrogen stations will be required to report these emissions and their use of renewable resources.

2. Greenhouse gas emission reductions

- a. Legislation – WTW greenhouse gas emissions from hydrogen powered vehicles must be 30 percent less than WTW greenhouse gas emissions from the average new gasoline vehicle.
- b. Intent - The intent of the requirement is to ensure that hydrogen used for transportation produces less global warming emissions when compared to gasoline.
- c. Discussion – This regulation will apply the definition of greenhouse gases used in existing climate change regulations adopted by ARB. Baseline GHG emissions for the average new gasoline vehicle will be determined from ARB’s Low Carbon Fuel Standard Regulation currently being developed. In the interim, during the development of the LCFS regulation, the current assumption for GHG defined in Part 1: Technical Analysis by University of California Berkley and Davis² will be used. This document provides a value of 92 grams of carbon dioxide per megajoule (gCO₂/MJ) for the Average Fuel Carbon Intensity (AFCI) of gasoline and will be the interim baseline for SB 1505. Once a final ruling is made on the LCFS and a baseline is determined, that new baseline will be incorporated into this regulation. Also, as required in SB 1505, that baseline will be reviewed periodically and strengthen if it is technically feasible.

Additionally, SB1505 requires that GHGs be measured on a gram CO₂ equivalent per mile basis; therefore, vehicle fuel efficiencies will have a role in the overall emissions. The value 92 gCO₂/MJ has vehicle efficiencies metrics built into it and, for the purpose of meeting this regulation, a conversion factor of 4.68 will be used to determine the baseline gCO₂/mile value yielding a baseline of

² Farrell, Alexander, Sperling, Daniel “A Low-Carbon Fuel Standard for California. Part 1: Technical Analysis” http://www.arb.ca.gov/fuels/lcfs/lcfs_uc_p1.pdf, May 29, 2007

430 grams of carbon dioxide equivalent per mile (gCO₂e/mi). This conversion factor was developed from the fuel energy megajoule per gallon (MJ/gal) and vehicle efficiency assumptions (miles per gallon) incorporated in the SAFP. Once the 3,500 metric ton hydrogen threshold level is reached within the state, efficiencies for hydrogen vehicles will be determined using available ARB certification data and will be reviewed during the four year periodical reviews.

- d. How can it be met - The requirement can be met by using low carbon or carbon neutral feedstocks and by employing methods of hydrogen production that minimize greenhouse gas emissions. The following graph depicts the WTW GHG emissions associated with five different production methods and model year vehicles for years 2012 and 2017 as developed in the Full Fuel cycle analysis for the SAFP. These values are compared to the current assumption for a converted APCI value.³ The study shows that all methods of hydrogen production currently meet these requirements with the exception of grid electrolysis. Electrolysis may need to incorporate a certain amount of renewable electricity to reduce overall GHG emissions.

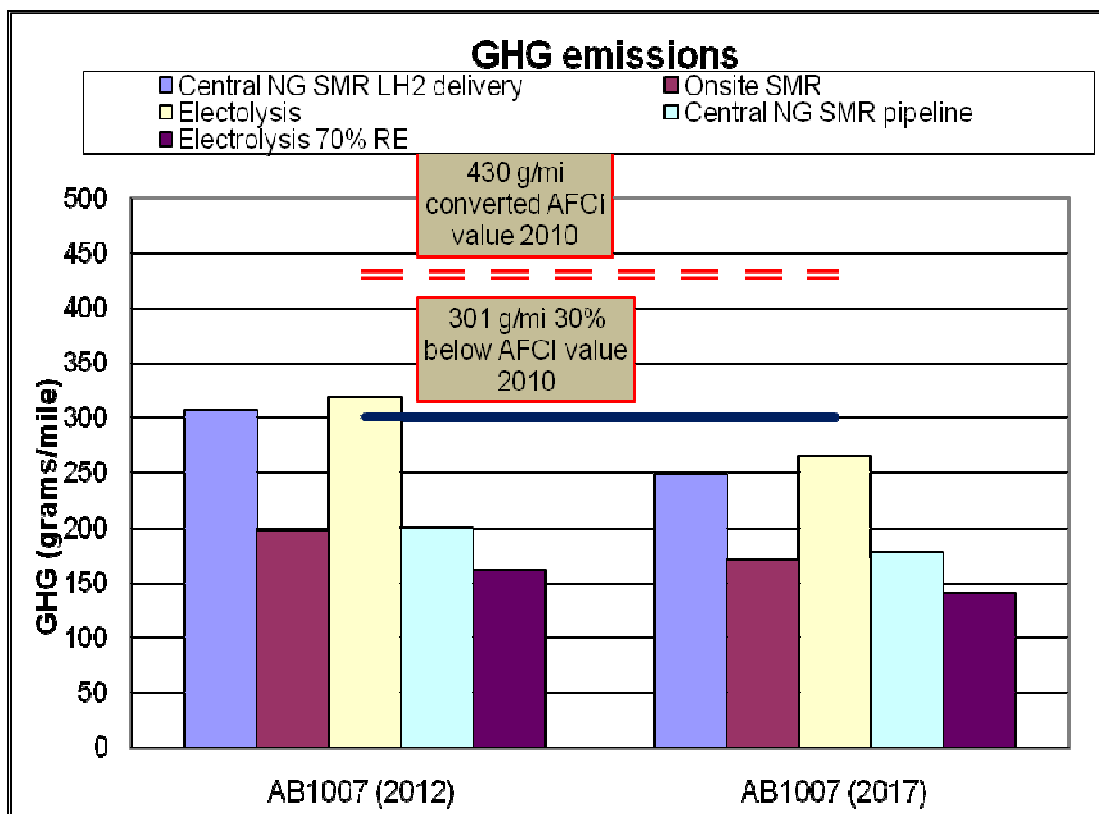


Figure 1. GHG comparison of LCFS gasoline baseline minus 30 percent versus five hydrogen pathways described in the SAFP.

- e. Requirement – ARB will require that providers of hydrogen fuel for transportation demonstrate compliance with this regulation by reporting production and delivery

³ Ibid.

methods along with the amount of GHG emissions generated on a WTW basis. Emissions can be calculated by using either: 1) an appropriate emissions model with agreed upon assumptions; 2) generalized assumptions provided by ARB; or 3) acceptable standard industry calculations. Reporting of production and delivery methods must include: feedstock source, transportation, storage, conversion process, hydrogen purification, gas compression or liquefaction, any other associated process, and delivery mode and distance, if applicable. The maximum allowable GHG emissions in the period between the regulation adoption and the four year review period will be 301 gCO₂e/mile.

3. Local NO_x plus ROG emission reductions

- a. Legislation – The legislation requires that local WTT emissions of NO_x plus ROG associated with hydrogen produced for transportation be at least 50 percent less than WTT emissions associated with the average motor gasoline sold in California on an energy equivalent basis.
- b. Intent – The intent of the requirement is to ensure that criteria pollutant emissions associated with hydrogen production and delivery do not affect local communities, and are reduced by 50 percent. Most urban areas have higher concentrations of criteria pollutants due to the density of transportation and industry. It is the intent of this requirement that, by introducing hydrogen as an alternative transportation fuel, local emissions of criteria pollutants will decrease when compared to gasoline, not only as a result of commercialization of zero or near zero emission vehicles, but also from improvements in fuel production and delivery pathways.
- c. Discussion - The regulation will provide a baseline WTT value for emissions of NO_x plus ROG associated with the average motor gasoline. This value will allow hydrogen providers to determine if they are meeting the 50 percent reduction requirement.⁴ Emissions of NO_x will be added to emissions of ROG on a gram per Gigajoule basis to form a total WTT value. The term “total” encompasses all stages of the fuel production process.

The baseline gasoline emissions are based on the marginal analysis used in the SAFP and discussed earlier in this White Paper. The SAFP used a modified version of the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET)⁵ model to determine emissions from various vehicle and fuel combinations. The model calculates emissions of VOC which will be used as ROG emissions. The WTT gasoline emissions for NO_x are 54.08 grams per gigajoule (g/GJ) and for ROG (VOC) are 12.41 g/GJ of dispensed fuel. This

⁴ As an alternative, this baseline may be provided in the compliance handbook required in SB 1505.

⁵ Wang, Michael “Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation version 1.7” Argonne National Laboratory Transportation Technology Branch.
<http://www.transportation.anl.gov/software/GREET/index.html>

gives a total WTT NOx plus ROG baseline for gasoline of 66.49 g/GJ. The 50 percent reduction from this level would require NOx plus ROG emissions for hydrogen production to be below 33.25 g/GJ of fuel dispensed. The SAFP also calculated emissions from multiple hydrogen production pathways on a marginal basis – these calculations can be used to evaluate whether a hydrogen production pathway can meet the 50 percent emission reduction requirement.

Staff will provide total WTT values for the most likely scenarios of hydrogen production. The hydrogen provider will have the option of either using these values or providing their own emissions data. For pathways that do not have ARB-provided total WTT numbers, the provider will be responsible for demonstrating compliance.

Total WTT emissions of NOx and ROG (VOC) from the modified GREET model are presented in Table 1. The table contains emissions for the baseline gasoline and six hydrogen pathways. The table shows that emissions of NOx and ROG for the hydrogen production pathways are at least 50 percent less than the baseline gasoline pathway.

However, this requirement does not include the local tank to wheel emissions from both gasoline and hydrogen vehicles. Therefore it reduces the complete benefits of hydrogen vehicle pathways displacing gasoline vehicles in urban areas. The intent is to reduce local emissions of NOx and ROG, to more accurately reflect this, the requirement should be based on a local well to wheel emissions.

AB1007 modified GREET values	NOx (g/GJ)	ROG (g/GJ)	Sum of “Total” emissions (g/GJ)
“Total” WTT emissions			
CA RFG marginal	62.43	13.76	76.19 / (38.1)
H2 NG SMR LH2	17.91	16.70	34.61
H2 NG SMR LH2 (100% RE)	11.79	9.91	21.70
H2 onsite NG SMR GH2	9.71	10.76	20.47
H2 onsite NG SMR GH2 (100% RE)	8.39	9.3	17.69
H2 electrolysis	14.92	16.54	31.46
H2 electrolysis (70% RE)	5.68	6.29	11.97

Table 1. Total WTT NOx and ROG emissions from Gasoline and Hydrogen pathways in the SAFP (g/GJ)

- d. How can it be met – The emission levels can be achieved by using methods of hydrogen production and delivery that currently meet the levels or use methods that produce lower emissions on an energy equivalent basis compared to average gasoline. Control methods such as NOx reduction devices can be a step to reducing emissions. Marginal emissions values for NOx and ROG described in both the SAFP and the California Hydrogen Highway Blueprint Plan show multiple compliance pathways that are currently available.

- e. Requirement - ARB will require station owners to report the amount of NO_x and ROG produced on a gram per unit energy basis such as grams per Gigajoule of hydrogen dispensed. ARB may accept emissions estimates based on equipment specifications, process efficiencies, and throughput.

4. No increase in TACs compared to gasoline

- a. Legislation – The legislation requires that, on an energy equivalent basis, WTT emissions of relevant TACs from hydrogen fuel be reduced to the maximum extent feasible when compared to the WTT emissions associated with gasoline. It further requires that in no case shall TAC emissions from hydrogen be greater than the WTT emissions associated with average motor gasoline fuel.
- b. Intent – Similar to the requirement for NO_x plus ROG, this requirement would ensure that TACs affecting local communities are minimized when providing hydrogen for transportation. The language of the legislation requires a WTT view of toxic emissions while the intent seems to be focused on the local impacts of toxics.
- c. Discussion – If the intent of this requirement is to focus on TAC impacts to local communities, ARB may want to compare the localized impacts of both fuel supply and vehicle operation since gasoline vehicles emit toxic air contaminants. The Consultant analysis⁶ for AB 1007 provides WTW emission factors for the following five TACs: acetaldehyde, benzene, 1,3-butadiene, formaldehyde, and diesel particulate matter. The analysis includes emissions from multiple fuel pathways including gasoline and hydrogen which are presented in Figure 2. While there are other TACs associated with conventional and alternative transportation fuels, these contaminants are believed to be the most significant TACs associated with transportation.⁷ Therefore, ARB is proposing to use these five compounds to compare upstream emissions of relative TACs.

The emission factors presented below represent local (urban) WTW emissions provided in the Consultant Analysis; however, the analysis does not differentiate upstream WTT emissions from those associated with vehicle operation. Until WTT numbers are developed and adequately reviewed and vetted, ARB is proposing to evaluate compliance by comparing hydrogen TAC emissions to those of gasoline on a WTW basis.

⁶ Consultant Report: Full Fuel Cycle Assessment: Well-to-Wheel Energy Inputs, Emissions, and Water Impacts, State Plan to Increase the Use of Non-Petroleum Transportation Fuels, AB 1007 (Pavley) Alternative, Transportation Fuels Plan Proceeding, Prepared by: TIAX, LLC., June 2007, CEC-600-2007-004-F

⁷ J. Winebrake, H. Dongquan, M. Wang, Fuel Cycle Emissions for Conventional and Alternative Fuel Vehicles: An Assessment of Air Toxics, Center for Transportation Research, Argonne National Laboratory, ANL/ESD-44, August 2000.

The data in the following table indicates that, when weighted and added, WTW toxic emissions associated with the hydrogen production pathways included in the Consultant Analysis are lower than that of gasoline. The analysis indicates that, while formaldehyde emissions from power plants and engines contribute to the WTT toxic emissions associated some hydrogen production pathways, WTW toxic emissions associated with conventional fuels is significantly greater.

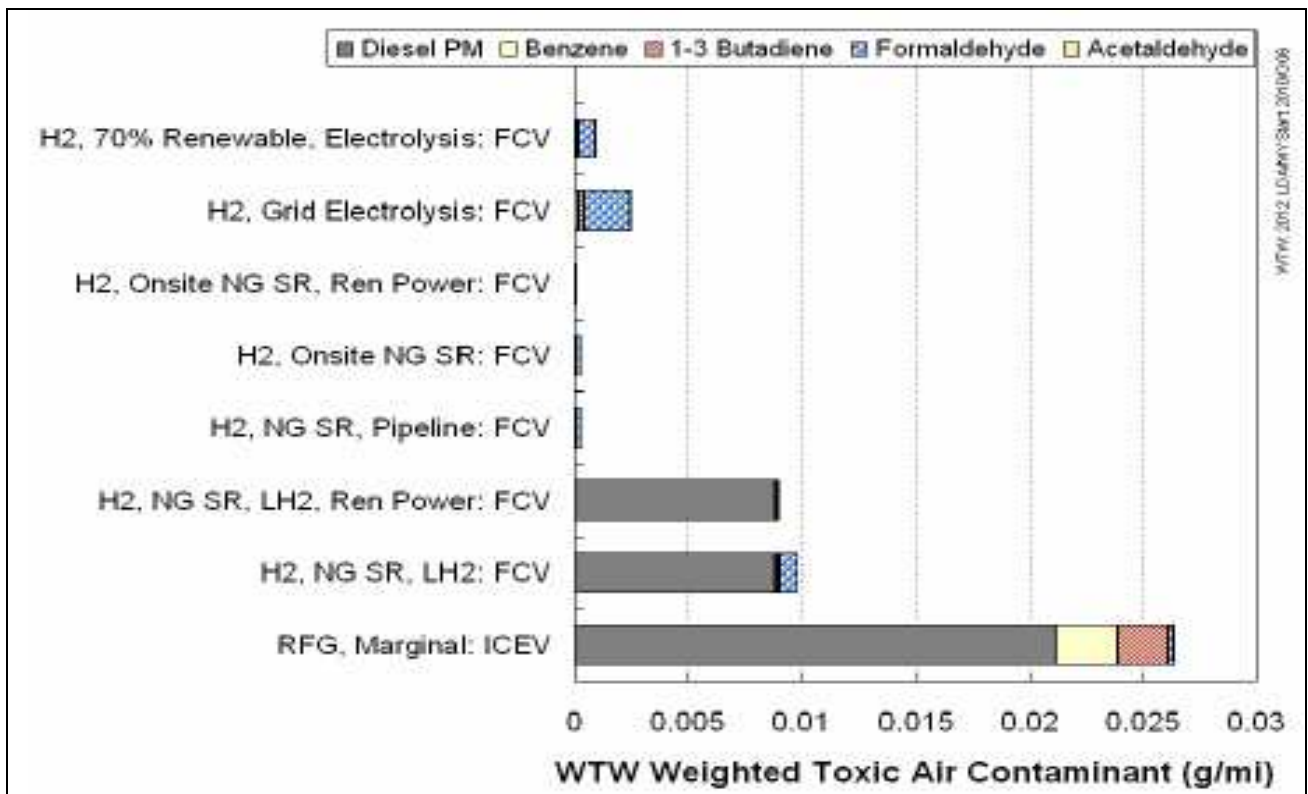


Figure 2. "Air Toxic emissions for Midsize Hydrogen Vehicles (2012 New Vehicle Stock)" AB1007

Source: Figure 3-34, Consultant Report, Full Fuel Cycle Assessment, TIAX, LLC, June 2007

NG SR = Steam reformation of natural gas

FCV = Fuel cell vehicle used in tank-to-wheel portion of analysis

Ren Power = electrical power demands met with renewable electricity

LH2 = hydrogen delivered in liquid form

RFG = California Reformulated gasoline

ICEV = internal combustion engine vehicle

- d. How can it be met – The emission levels can be achieved by using clean and efficient methods of hydrogen production, and low polluting delivery vehicles. If the emissions are considered on a WTW basis, most hydrogen production pathways will achieve the emissions requirements.
- e. Requirement –Hydrogen providers will be required to calculate their total relevant TAC emissions using emission factors and assumptions defined in AB 1007, or other operator-defined emission factors, to show they are lower or no worse than the gasoline baseline.

5. Use of renewable resources in hydrogen production

- a. Legislation – The legislation requires that, “on a statewide basis, no less than 33.3 percent of the hydrogen produced for, or dispensed by, fueling stations that receive state funds be made from *eligible renewable energy resources* as defined in Public Utilities Code (PUC) Section 399.12.” Once an annual threshold of 3,500 metric tons produced or dispensed is reached, the 33.3 percent renewable requirement will apply, on a statewide basis, to all hydrogen produced for transportation. The legislation prohibits hydrogen fuel producers from counting as a renewable energy resource any electricity that has been previously procured by a retail electricity seller towards meeting the Renewable Portfolio Standard (RPS) obligation.

PUC Section 399.12 defines *eligible renewable energy resource* as “an electric generating facility that meets the definition of “in-state renewable electricity generating facility” in Section 25741 of the Public Resources Code (PRC).

Section 25741 of the PRC defines “in-state renewable electricity generating facility” as a facility that meets a number of different criteria pertaining to renewable feedstocks, delivery of renewable electricity, and facility location and construction date. Section 25741(b)(1) lists renewable feedstocks that are eligible for renewable electricity generation. They include:

“biomass, solar thermal, photovoltaic, wind, geothermal, fuel cells using renewable fuels, small hydroelectric generation of 30 megawatts or less, digester gas, municipal solid waste conversion, landfill gas, ocean wave, ocean thermal, or tidal current, and any additions or enhancements to the facility using that technology.”

- b. Intent – The intent of the renewable requirement is, to ensure that hydrogen is a real part of California’s efforts to increase the use and development of renewables and to reduce dependence on non-renewable fuels like petroleum and natural gas.
- c. Discussion - This section will discuss the renewable requirement using two interpretations: the strict interpretation from the legislation, and a broader interpretation that is more in line with the intent of the legislation.

The legislation’s use of the PUC definition for “eligible renewable energy resources” does not give hydrogen producers the ability to meet this requirement as it intended. Section 399.12 of the PUC was written for electrical utilities that must comply with California’s RPS, and the definition for *eligible renewable energy resources* used therein applies specifically to the creation of renewable electricity. This definition precludes hydrogen produced directly from renewable

resources/feedstocks from being counted toward the statewide 33.3 percent renewable requirement. This limitation is not in line with the overarching intent of this legislation nor the findings of the California Hydrogen Blueprint Plan, which this legislation was based on.

In addition, electrical utilities serving the state of California are currently striving to meet a renewable electricity goal of 20 percent by 2010. According to the California Energy Commission's Annual Report to the Legislature,⁸ 10.9 percent of the electricity generation for the state in 2006 was provided by eligible renewable energy resources. As the state's electrical utilities strive to achieve 20 percent by 2010, the demand for eligible renewable energy resources will become more and more competitive. In light of the potential for increased competition with utilities for eligible renewable energy resources (discussed in 5.b.), it will be challenging at best for hydrogen providers to procure or install sufficient eligible renewable electricity to satisfy the statewide renewable requirement. Therefore, staff is suggesting that the renewable requirement be reduced to 23.3 percent.

Strict Interpretation: As the legislation is written, the renewable requirement could be understood in one of two ways:

- i. 33.3 percent of the hydrogen produced statewide for transportation must be made directly from renewable electricity as defined under PUC Section 399.12; or
- ii. 33.3 percent of the electricity used statewide for hydrogen production must come from eligible renewable energy resources as defined in PUC Section 399.12.

Broader Interpretation: Include hydrogen produced from either renewable electricity or directly from renewable resources as meeting the renewable requirement. With this interpretation, hydrogen producers can directly convert biogas, biomass, or other renewable feedstocks into hydrogen. Existing reformation processes that are well suited for natural gas can be adjusted to accept renewable biogas as a feedstock. Similarly, gasification processes that commonly use coal as a feedstock can also accept many renewable biomass resources. Producers using renewable feedstock would have extra incentive to pursue such opportunities through state funding when available. In addition, hydrogen is also a byproduct from several industrial production processes and, since it is not needed, the hydrogen is commonly vented to the atmosphere.

Using a broader definition to determine which "eligible renewable resources" would qualify towards the statewide 33.3 percent renewable requirement would be more in line with the intent of the legislation and California Hydrogen Blueprint Plan, and thereby, open the door to new experimental and proven technologies and ultimately help to foster growth in California's renewable energy market. This

⁸ Renewable Energy Program 2007 Annual Report to the Legislature, California Energy Commission, October 2007, CEC-300-2007-013-F.

broader definition should include:

- i. renewable feedstocks listed in (PRC) Section 25741(b)(1);
 - ii. electricity produced in-state from the renewable feedstocks listed in PRC Section 25741(b)(1); and
 - iii. hydrogen generated as a by-product of a production process, which would otherwise be discharged to the atmosphere (i.e., hydrogen byproducts).
- d. How can it be met? – This section discusses the use of statewide compliance targets and provides examples of how producers could integrate renewables into hydrogen production using both the strict and broader interpretations of eligible renewable resources.

A statewide compliance target acknowledges the fact that renewable resources are seldom located where fueling stations are needed. As a result, not all stations will have to incorporate renewable resources into their production. Some stations may produce 100 percent renewable hydrogen and some may produce no renewable hydrogen, as long as 33.3 percent of the hydrogen dispensed for transportation is considered renewable.

Compliance for state funded stations will be assessed in aggregate. Compliance for non-state funded stations will be assessed by the individual provider's aggregate.

Strict interpretation: With this interpretation, the renewable requirement can only be met by ensuring that, 33.3 percent of the electricity used to produce hydrogen for transportation is eligible renewable electricity as defined earlier. In addition, to qualify toward the 33.3 percent requirement, the following conditions must be met:

- i. the renewable electricity produced or purchased accounts for at least 33.3 percent of the electricity required to produce the hydrogen for transportation;
- ii. if the new renewable electricity is produced on-site, then electricity generated must be connected to the California grid system;
- iii. if the new renewable electricity is produced off-site, then it must be produced in-state and delivered to the California grid system; and
- iv. renewable electricity that is being counted or credited towards the production of renewable hydrogen cannot also be counted toward the California RPS or any other program.

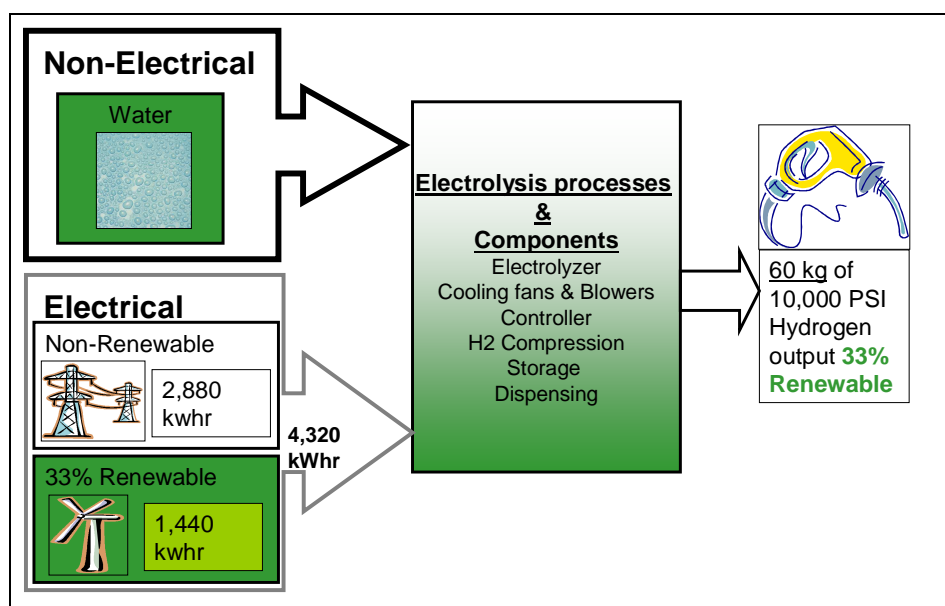
If the strict interpretation for renewables is applied, ARB staff will consider allowing hydrogen producers to offset the electricity, which is used to produce hydrogen for transportation, by purchasing renewable energy certificates (RECs) provided those credits are real, enforceable, quantifiable, surplus, and contemporaneous, and a system is in place to verify that the RECs have not already been sold to another buyer or counted towards a renewable requirement of any other program. The

provider would be responsible for verifying that the RECs they purchase meet the conditions of Public Utilities Code Section 399.12.

Stations currently employing renewable resources are doing so by meeting their electrical energy demands with solar panels or purchasing RECs. For example:

- Solar panel arrays provide 100 percent of the energy needed to produce the hydrogen dispensed at South Coast Air Quality Management District's (SCAQMD) Diamond Bar station. This electricity is produced and sent to the grid during the day and hydrogen is produced via electrolysis at night during off-peak hours. It is acceptable for SCAQMD to credit their solar electricity toward their renewable hydrogen goals as long as the electricity was not already counted toward a utility's RPS.
- The SunFuels station, operated by Sunline Transit Agency, reforms hydrogen from natural gas and meets their electrical demands using on-site solar panels.
- The City of Santa Monica's hydrogen is produced via electrolysis. Since the City purchases 100 percent of their electricity from a renewable energy provider the hydrogen is 100 percent renewable, contingent upon the renewable energy provider's facility meeting the definition of an "in-state renewable electricity generating facility."

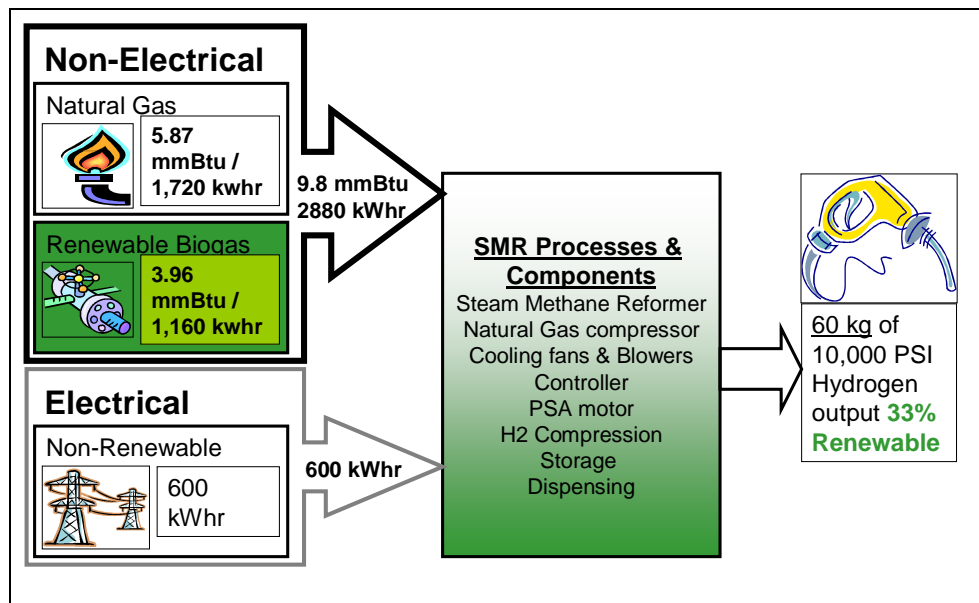
The following graphic illustrates an electrolysis station producing 60 kilograms of hydrogen per day and using 33.3 percent renewable electricity.



Broader Interpretation: Providers can contribute to the statewide requirement by directly using renewable feedstocks to produce hydrogen, using renewable electricity as discussed above, or extracting hydrogen by-products from the stack gas of an existing process. The percent renewable is calculated using the energy content (i.e., in btus or kWhr) of all of the energy inputs needed to produce the hydrogen for transportation – electrical, non-electrical, renewable and non-

renewable. For example, a hydrogen producer reforming biogas to hydrogen would quantify, in the same units, the energy content of the biogas feedstock and all other renewable and non-renewable energy inputs, and then divide the renewable portion by the total energy inputs to determine their percent renewable. If a hydrogen producer is extracting a hydrogen by-product from a stack gas and using no other renewable resources, the renewable percentage would be the energy content of the hydrogen divided by the total energy inputs, including the hydrogen and its capture, separation, cleanup, and compression.

The following graphic illustrates a steam methane reformation station using a blend of natural gas and renewable biogas to produce 60 kilograms per day of hydrogen, with non-renewable electricity supporting the other operations needed to produce the hydrogen for transportation. The hydrogen produced at this example station is 33.3 percent renewable because biogas comprises 33.3 percent of the total energy inputs.



- e. Requirement – Staff suggests that two exemptions be pursued. The exemptions would assist in the development of the hydrogen highway. The first exemption is for a reduction in the renewables required by 10 percentage points from 33 percent to 23 percent. Staff determines that the 33.3 percent renewable hydrogen requirement is a deterrent to the technology during early stages of deployment that results in significant cost. The large initial requirement will not allow new methods of renewable hydrogen to develop and only create a barrier for developing technology. Staff has also considered the fact that no other transportation fuel regulations currently contain a renewable requirement. Also, current amounts of renewable hydrogen used today compromise less than 4 percent of the available hydrogen.

The second is the exemption for public transit operators to use non-renewable hydrogen for a period of five years. Large transit operators are required to meet

stringent vehicle emissions requirements and purchase bus technology that ensures future emissions reductions, and until there is increased availability of renewable hydrogen they should be exempt from the requirement. Transit operators already reduce emissions per person mile traveled and are helping to push zero emission technology development while meeting their primary mission of providing public transportation. Transit operators should be encouraged to increase ridership resulting in less vehicle miles traveled and lower emissions.

For state co-funded stations, ARB will be responsible for ensuring compliance with this requirement through the Request for Proposal process and the allocation of hydrogen highway funding. The state can only co-fund hydrogen stations that, in aggregate, meet the renewable requirement.

Once the threshold is reached, the operators of hydrogen stations will ultimately be responsible for demonstrating their role in contributing to the statewide requirement. There are a number of different ways that this could play out:

- i. Delivered hydrogen: A station that purchases hydrogen from a third party would require the hydrogen producer to verify the renewable content of the hydrogen as a condition of sale.
 1. If no additional energy is required to dispense the hydrogen (i.e., mobile fueler), the renewable percentage is as reported by the hydrogen provider.
 2. If the additional energy is required to prepare the delivered hydrogen (i.e., convert liquid to gas, additional compression), that energy will count towards the total energy requirement and the percent renewable calculation.
- ii. Two or more stations owned and operated under one entity: Regardless if the hydrogen is produced on or off site, the entity must meet the 33.3 percent requirement based on the amount of hydrogen they dispense for transportation statewide.
- iii. One station operated under one entity: If an entity owns and operates only one station in the state, they must demonstrate that 33.3 percent of the hydrogen they dispense for transportation is made from renewables, regardless if the hydrogen is delivered or produced on site.